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The development of chemistry concept in 7th grade and 11th grade: A cross-age study

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Abstract

The purpose of this cross-age study is to determine that whether the development of the chemistry concept throughout history has similarities with the students' conceptual development of "chemistry" in different grades. The study was carried out with a cross-sectional research in the form of a case study. According to the findings, chemistry concept is constructed in students' minds related to their grades. There is a direct relationship between the construction and the historical development of the concept. In order to overcome misconceptions about the "chemistry" concept and to teach it meaningfully concept mapping, prediction-observation-explanation, interviews about concepts, drawings, fortune lines, relational diagrams and word association techniques are suggested for teachers.

Keywords: Chemistry concept; concept development; historical development; conceptual learning; cross-age study.

1. Introduction

Many words in science are often used to define some scientific concepts or to facilitate the conceptual development of the student. Conceptual development is one of the major aims of the instruction because if students do not have an understanding of science language, they definitely have difficulty in science and lack of interest with their science material (Young, 2005). Thus, the concept and concept formation has gained importance and educators have developed different ways of concept teaching (Driver and Easley, 1978; Seiger-Ehrenberg, 1981; Novak, 1990). According to Cox and Fenton (1990), there are three sources pushing science educators toward concept based science programs. The first two of them are related to the professional organizations' reports and recommendations indicating the poor quality and quantity of science education such as NSTA, National Commission on Excellence in Education, and the National Science Board Commission on Precollege Education in Mathematics, Science and Technology. The last source aroused from the researches indicating that students' conceptual development should be taken into account to provide and keep the scientific understanding.

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According to Birbili (2007), in today's world, instead of teaching students all the facts, teachers could help them see relations between different themes. Birbili explained the importance of concept development in education in her article:

It is now widely accepted that facts alone are not enough to help children discern patterns and relationships, group things together, see big ideas and solve problems. Facts need to be placed in a conceptual framework to be understood and remembered. Teachers can facilitate concept development by putting concepts and generalisations (rather than facts) at the centre of activities, providing children with a wide variety of tangible experiences, helping them learn how to observe and represent what they see and hear and providing them with multiple examples of the concepts being taught (p. 141).

The concept of chemistry has an origin of "chem" meaning black country in ancient Egyptian language and "chemeia" in Greek language. But it is more logical that chemistry arises from "chyma" meaning metal pouring in Greek language if chemistry's definition was taken into consideration. Some science historians translated alchemy into Turkish as "El-kimya" and into Arabic as "simya" (Tez, 1986). It is supposed that chemistry has existed from the very beginning of civilization. To make a fire, to produce a pot or ceramics, and to get iron and bronze were the first chemical activities human being was interested in because of their needs (Berkem, 1996). Compulsorily, the first chemist was the first man who made a fire in the world (Vlasov *et al.,* 2003).

When the historical development of the chemistry concept taken into account, it can be said that chemistry has evolved with the alchemy and then the process of metals, cosmetic, dye, ceramic and so on. It is wondered that the conceptual development of chemistry in students' minds has evolved in the same way of the chemistry's historical development. Therefore, the purpose of this cross age study is to determine that whether the development of the chemistry concept throughout history has similarities with the students' conceptual development of "chemistry" in different grades.

2. Methodology

The study was carried out with a cross-sectional research in the form of a case study because cross-sectional research does not require too much time. This method lets the study take place in a shorter time with different sample groups having similar characteristics. Therefore, to finish the study, there is no need to study with the same sample group in large time periods. And also lets to use qualitative and quantitative methods at the same time (Çepni, 2007).

The sample group was 7 and 11th grades students in Giresun. Firstly, a chemistry test was applied to 98 students to collect data. The test had 2 open-ended, one drawing and one multiple choice questions. The first question in test was required writing about the first five things appearing in students' minds about chemistry. The second question was required writing in order to control whether students were aware of chemistry's topics or sub-topics. The third question was a free drawing question and it required students to draw a chemical event. The last question was a multiple choice question and it required students to choose the pictures related to chemistry directly or indirectly. This test was analyzed with qualitative methods. The themes of students' answers and their frequencies were determined according to the levels. With the help of the data handed from the test, a new Likert test consisting 12 questions was constructed. The Likert test was applied to 20 students in the interviews in order to reveal students' real ideas and the reasons behind their answers of the first chemistry test.

3. Findings

3.1. Data collected from the first open-ended question: Please write down the first five concepts appearing in your mind about "chemistry".

35 7th grade students out of 55 used experiment and observation concept when they heard "chemistry". 21 of students said that chemistry is a course, and 19 of them used "matter" concept. However, 19 11th grade students out of 43 used "atom" concept when they heard "chemistry". 16 students said that chemistry evoked chemical reactions, matter, chemistry teacher or chemist, and experiment and observation. 15 of them used periodic table concepts.

3.2. Data collected from the second open-ended question: What can be the topics or subtopics of chemistry?

While 19 students of 7th grade students wrote that “matter” was the topic of chemistry. 15 students wrote that chemistry was a branch of science. 11 students gave an answer of atom as a topic of chemistry. Similarly, 25 students of 11th grade students wrote that “matter” was the topic of chemistry. 9 students gave an answer of atoms and chemical reactions as the topics of chemistry. 8 students wrote that chemistry’s topic was drugs.

3.3. Data collected from the drawing question: Please draw a chemical event.

Most of 7th grade students drew an experiment picture (19 students out of 55 students), 8 students drew a transition state picture, and 3 of them drew an element or compound picture. 19 students did not draw any pictures. Most of 11th students drew a chemical reaction picture (13 students out of 43 students), 5 students drew an experiment picture, and 4 of them drew a gas or gas pressure picture, rest of them drew atomic structure or something else. 7 students did not draw any pictures. Two examples of students’ pictures are given below.

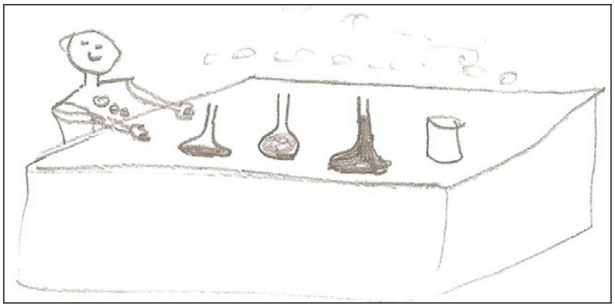

Figure 1. A 7th grade student’s drawing of a chemical event: experiment and observation

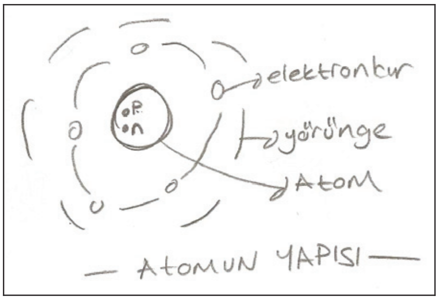

Figure 2. A 11th grade student’s drawing of a chemical event: atomic structure

3.4. Data collected from the multiple choice question: According to you, choose the picture(s) which are related to chemistry directly or indirectly.

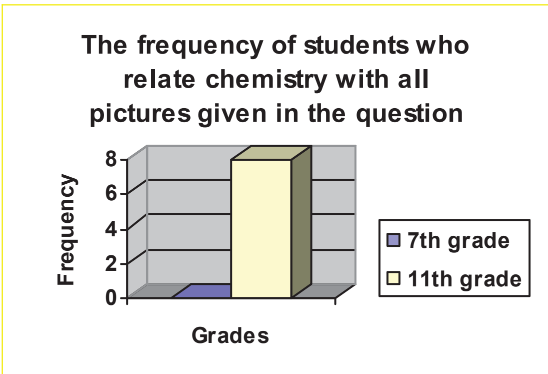

Figure 3. The frequency of students who relate chemistry with all pictures given in the question.

As seen in the figure 3, none of 7th grade students related chemistry with the pictures by selecting all of them. 8 students in 11th grade students marked all the pictures and it can be said they established a relation between chemistry and the pictures directly or indirectly.

3.5. Data collected from the sample through Likert test during interviews

With the help of the data handed from the above test, a new Likert test consisting 12 questions was constructed. The sentences used in the Likert test were taken from the chemistry test. The Likert test was applied to 20 students (10 students from each grade) in the interviews in order to reveal students' real ideas and the reasons behind their answers of the chemistry test for the drawing and multiple choice questions.

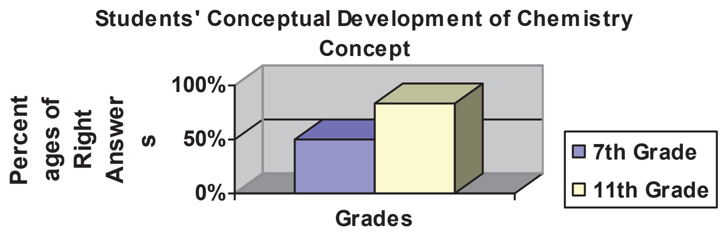

Figure 4. Percentages of right answers of the Likert test questions of 7th and 11th grade students.

Figure 4 shows the percentages of right answers of the Likert test through the different grades. As seen in figure 4, percentages of students' right answers are increased in accordance with the grades. Therefore, conceptual development of chemistry concept in students is also increased. While 7th grade students' development was 50%, and 11th grade students' development was 83,3%.

4. Discussion and Conclusion

According to data obtained from the first question of the chemistry test, the majority of 7th grade students established a strong relation between "chemistry" and "experiment and observation". But 11th grade students pointed the relation between chemistry and atom. The reason of choosing experiment and observation may be that 7th grade students were affected from their environment, TV or friends studying at high school. Because 7th grade students did not have adequate information about chemistry, when they heard chemistry concept, experiment came in their mind. This consequence is valid for the findings of the third question. In the drawing question, 7th grade students established a strong relation between "chemistry" and "experiment and observation", therefore they mostly drew an experiment picture. But 11th grade students drew chemical reactions pictures.

When the findings of the second question are taken into account, it is clear to see that most students of both grades said that matter was a topic of chemistry. The rationale of choosing "matter" may be that students firstly learned the matter and its properties topic in a science or chemistry course, so they easily connected the matter with the chemistry.

According to the data obtained from the fourth question, 7th grade students chose the experiment, chemical detergents, and aspirin pictures which are related to chemistry directly or indirectly. They were not ready to relate chemistry with all the pictures. But eight of 11th grade students marked all the pictures. This shows us students improved an understanding of the relation of chemistry with everything around us. Students developed a feeling such that if chemistry is about matter, then everything is connected with chemistry because everything is a matter. This is a good point for the development of chemistry concept.

When the findings of interview are considered, it is possible to see that students gave more logical answers to the Likert test and they could explain the reason why they chose the option according to the grades. For example 7th grade students marked 6 questions out of 12, and 11th grade students chose 10 correct options. Students of 11th grade were more self-confident while they were responding and explaining the questions. The reason may be that they were studying a lot because 11th grades students will enter the university entrance exam one year later, therefore they were more interested in lessons. As understood from the Likert test and interview findings, chemistry concept's development improves with grades. While 7th grade students' development was 50%, 11th grade students' development was 83,3%.

In the literature, there are alike studies searching the conceptual development via cross-age methods (Coll and Treagust, 2003; Ünal *et al.,* 2006; Şahin *et al.,* 2008). The results of these studies showed similarities. The concept development of some concepts was almost the same. At the beginning of the study, our research questions were: does the conceptual development increase with grades? And if so, is it similar to the historical development of the concept? Our first question is answered when the findings are considered. But in order to answer the second one it is necessary to look at the history of chemistry. Chemistry arised from alchemy, i.e, from metals and metal pouring. It was a very limited area for chemistry in contrast to today's world. Today, chemistry has relations with almost all areas of industry, medicine, manufacturing, dye, cosmetic, and so on. 7^{th} grade students relate chemistry concept with 18 different concepts, and 11^{th} grade students 33 different concepts. Thus, it is possible to say that there is consistency between the developments of the chemistry concept in students with the historical development of chemistry throughout history.

5. Suggestions

It is extremely difficult to teach scientific abstract concepts to students and also to create a mental image in students' minds. Reports and tests identified that even if students learned the concept, they failed at the application of it to the new situations (Seiger-Ehrenberg, 1985). To teach students basic concepts can facilitate students' learning of whole subject. According to Novak (2006), it is necessary to learn main concepts for meaningful learning. And concept maps are beneficial tools in order to teach the concepts and to find out the relations between concepts. Therefore, teachers should use concept maps in their instructions. If not, students do not learn the concepts completely or they have misconceptions. Gilbert, Osborne and Fensham (1982), named misconceptions as children's science (cited by Duit and Teagust, 2003), Hewson and Hewson (2003), named as alternative conceptions. In order to determine students' knowledge and to remove their alternative conceptions, there are a lot of methods such as concept mapping, prediction-observation-explanation, and interviews about concepts, drawings, fortune lines, relational diagrams and word association techniques (White and Gunstone, 1992). Teachers should use such methods in their classrooms in order to overcome the students' misconceptions. Using these methods will help students learn the subjects meaningfully.

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